EXPEDIENT DRAINAGE

OVERVIEW

- Plan and design adequate drainage
- Types of drainage systems
- Purpose of adequate drainage
- Maintaining a drainage system

OBJECTIVES

- Terminal Learning Objectives
- Enabling Learning Objectives

METHOD / MEDIA

- Lecture method
- Power point
- Demonstration
- Practical application

EVALUATION

- Written exam

SAFETY / CEASE TRAINING

- Classroom Instruction
  - No safety concerns for this period of instruction
- Inclement weather plan
- Fire exit plan

QUESTIONS?

- Are there any questions concerning:
  - What will be taught?
  - How it will be taught?
  - How the student will be evaluated?

SOURCES OF WATER

- Precipitation
- Interception
- Infiltration
- Ground Water

PRECIPITATION

- Rain Fall
- Snow Fall/Melt
- Humidity

INTERCEPTION

- Interception is the process of vegetation absorbing the water before it reaches the soil.

- Once the holding capacity of the vegetation has been reached, the soil will then start receiving water.

INFILTRATION

- Infiltration is the waters ability to penetrate the soil surface. The following factors affect the process of infiltration:
- Vegetation presence or lack there of.
- Soil type. (some soil types retain water more than others.)
- Slope of terrain.

GROUND WATER

- Surface water: Surface water is retained in the top soil. (depended upon vegetation and soil type.)

- Sub-surface water: Water that is present below the ground. (water table).

- Capillary water: The water that seeps to the surface.

QUESTIONS?

- Any questions?
- Questions for you!!

ESTIMATING WATER RUNOFF

- Methods of estimating water runoff
  - Hasty
  - Field Estimate

HASTY METHOD

- The hasty method is used when an existing stream crosses or interferes with your construction site.
- Certain measures must be taken to avoid possible water damage to your construction site.
- Using the following formula, we can determine the “Area of Waterway” (AW)

HASTY METHOD

$$AW = \frac{WI + W2}{2} \times H$$

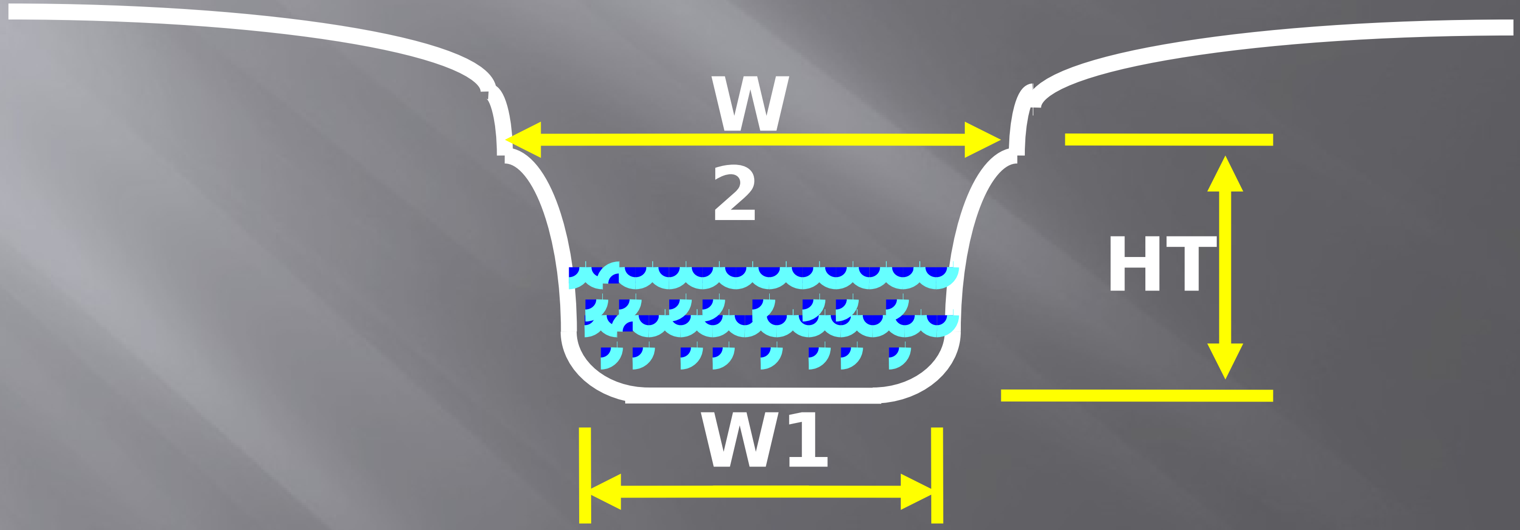
AW = Area of the waterway

W1 = Width of the channel bottom

W2 = Width at the high water mark

H = Height from the bottom to

HASTY METHOD



DRAINAGE SAFETY FACTOR

$$ADES = 2AW$$

ADES = Design cross section

2 = Safety Factor

AW = Area of the waterway that was previously computed

EXAMPLE # 1

$$\frac{7 + 9}{2} \times 4 = 32 \text{ Sqft (AW)}$$

$$32 \text{ Sqft} \times 2 = 64 \text{ Sqft (Ades)}$$

EXAMPLE # 2

$$\frac{5 + 7}{2} \times 3 = 18 \text{ Sqft (AW)}$$

18 Sqft x 2 = 36 Sqft (Ades)

COMPLETE HANDOUTS 1 & 2

PRACTICAL APPLICATION

REVIEW

- Review handouts #1 and #2
- Take a Break

FIELD ESTIMATE METHOD

- The field estimate method is used to estimate the peak volume of storm water runoff.

- Results of this method are adequate for determining the size of drainage structures for temporary drainage in areas of 100 acres or less.

FORMULA

$$Q = 2 \times A \times R \times C$$

Q = peak volume of storm water runoff, in cubic feet per second

2 = safety factor (constant)

A = area of drainage basin, in acres

R = design rainfall intensity based on the one hour, two year frequency rainstorm, in inches per hour

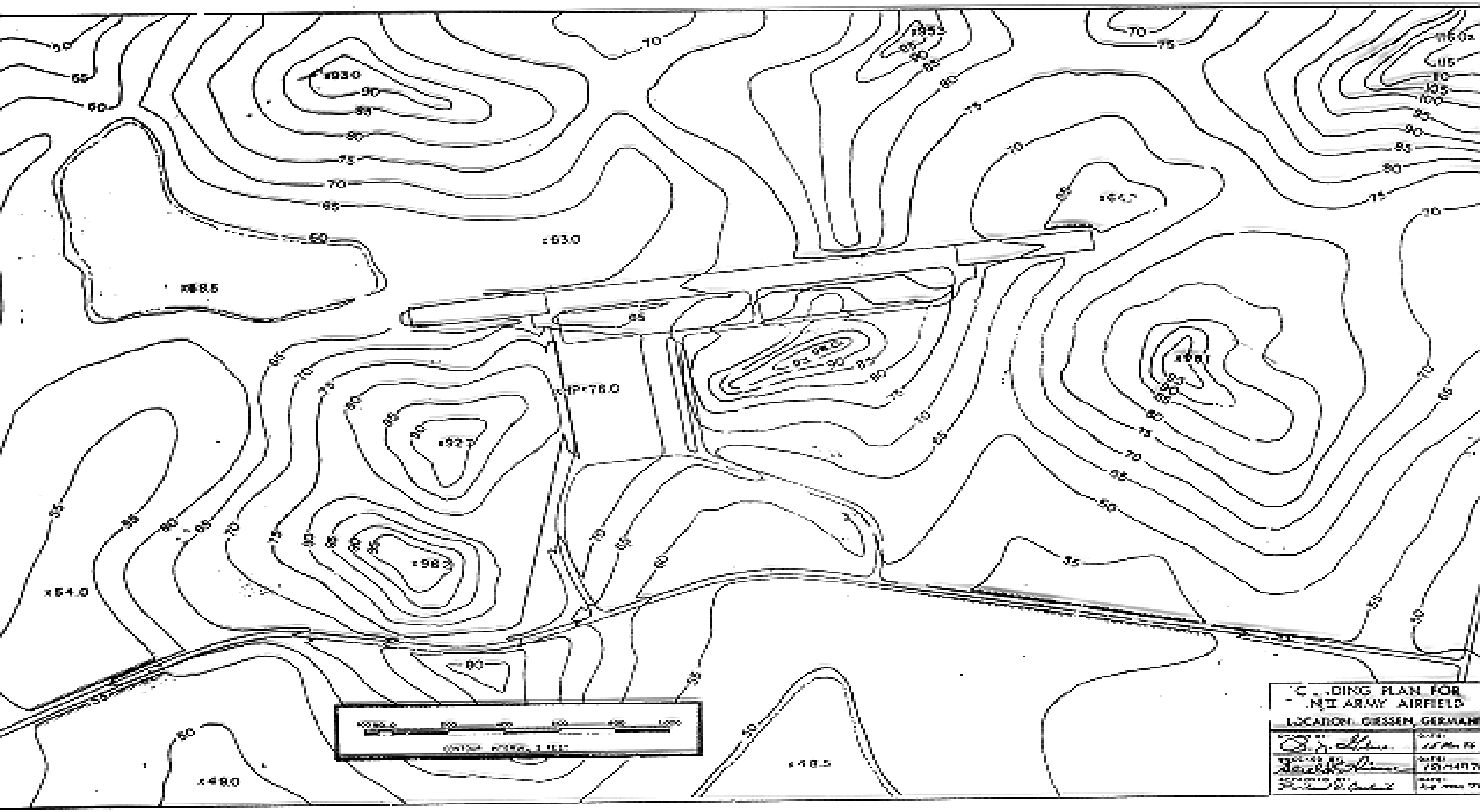
C = coefficient representing a ration of runoff to rainfall

DRAINAGE AREA

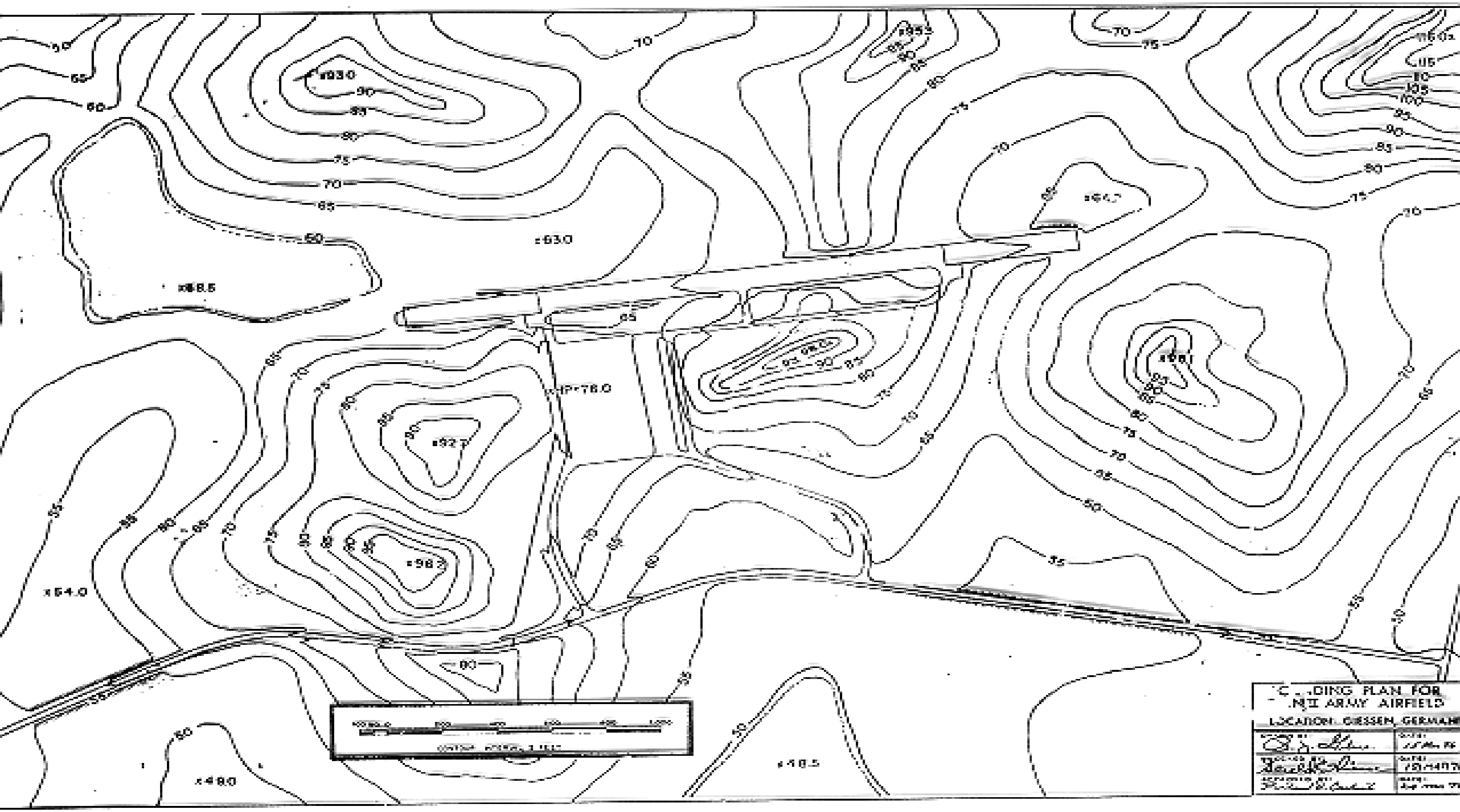
- The fastest and most preferred method for determining the size of the drainage area is the stripper method

- The first step is called delineation. (Done on a topographic map)

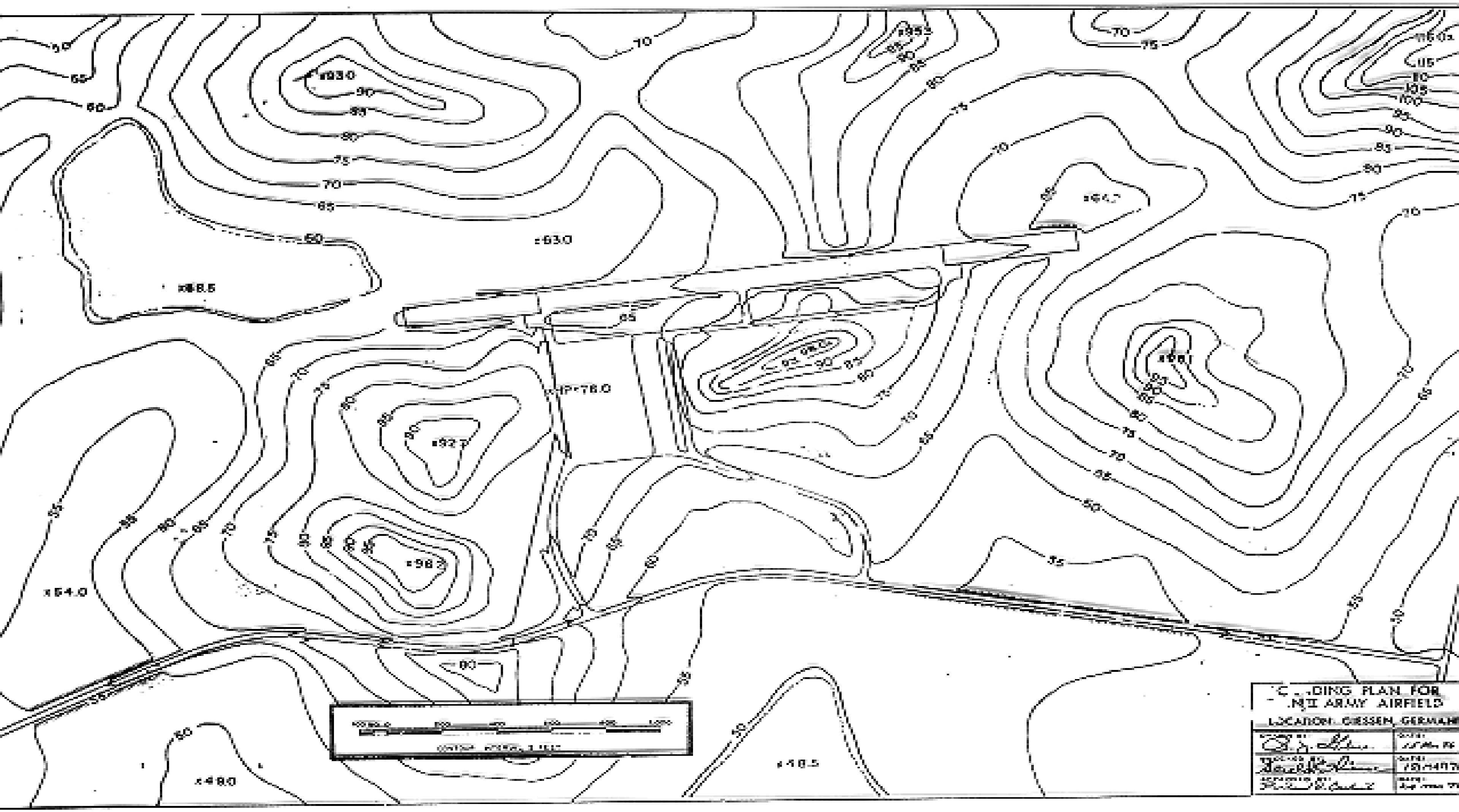
LOCATE HILLTOPS IN THE VICINITY OF THE CONSTRUCTION SITE



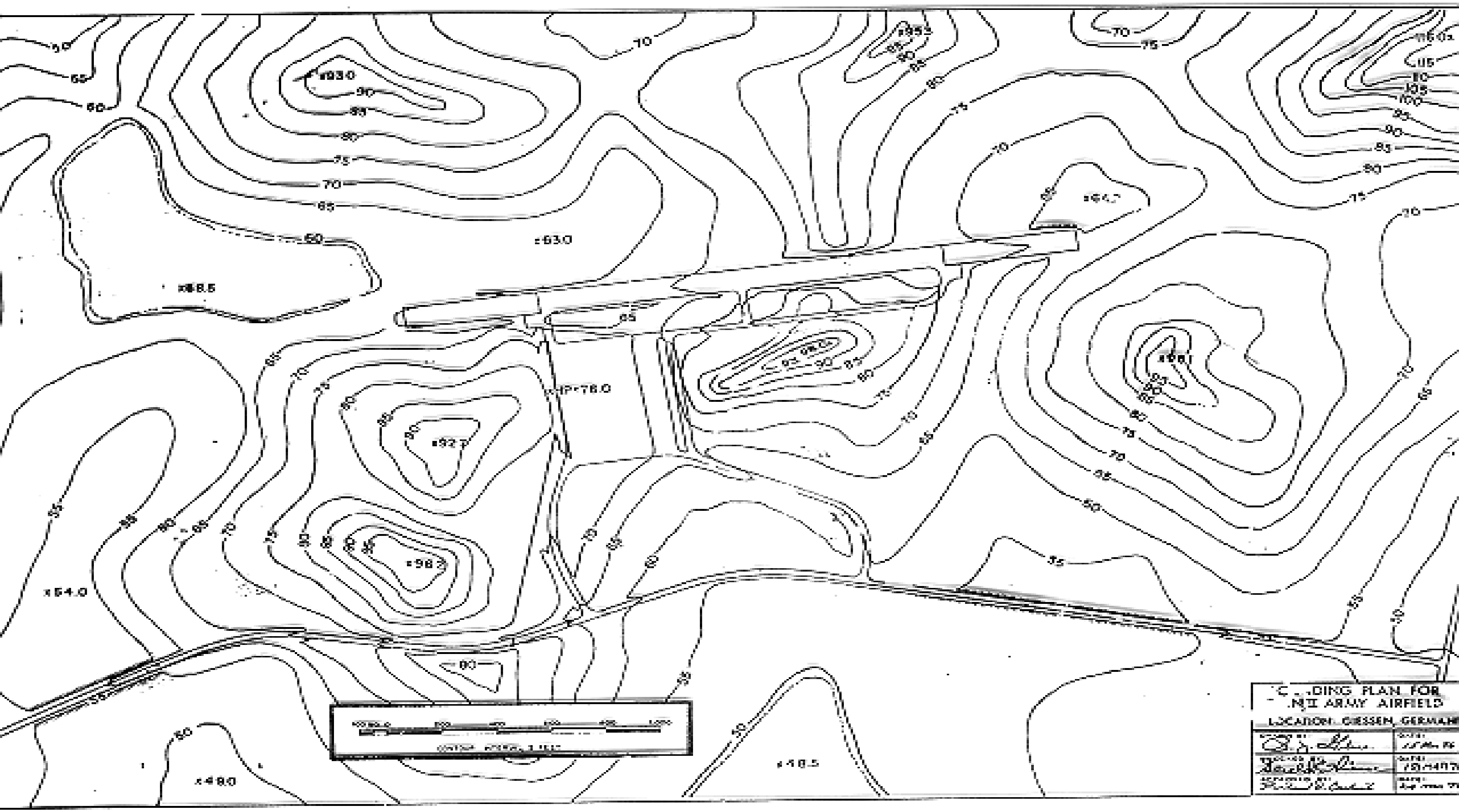
DRAW ARROWS THAT FOLLOW THE CONTOUR LINES FROM THE HILLTOP DOWN



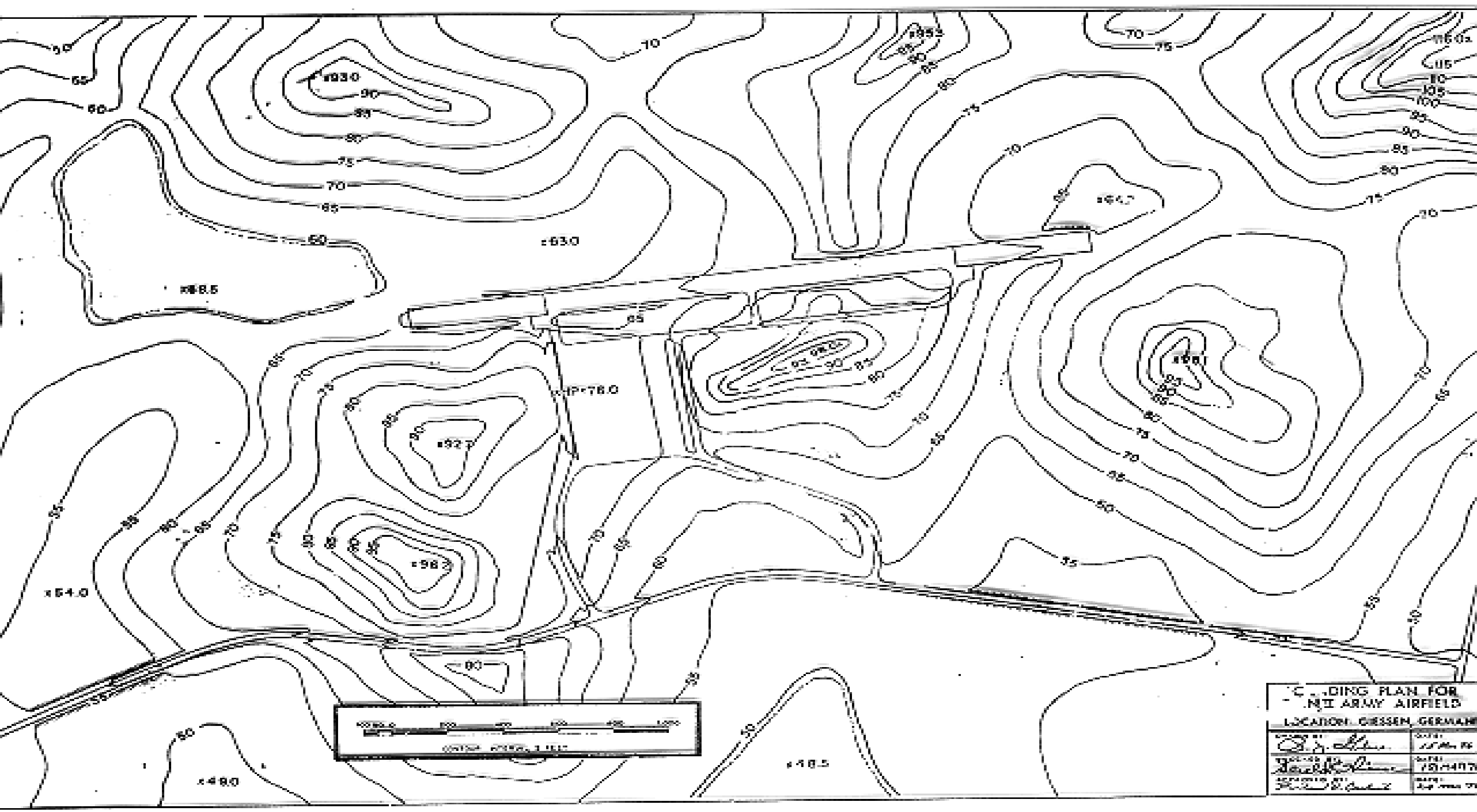
DRAW LINES FROM HILLTOP TO HILLTOP TO OUTLINE AN AREA



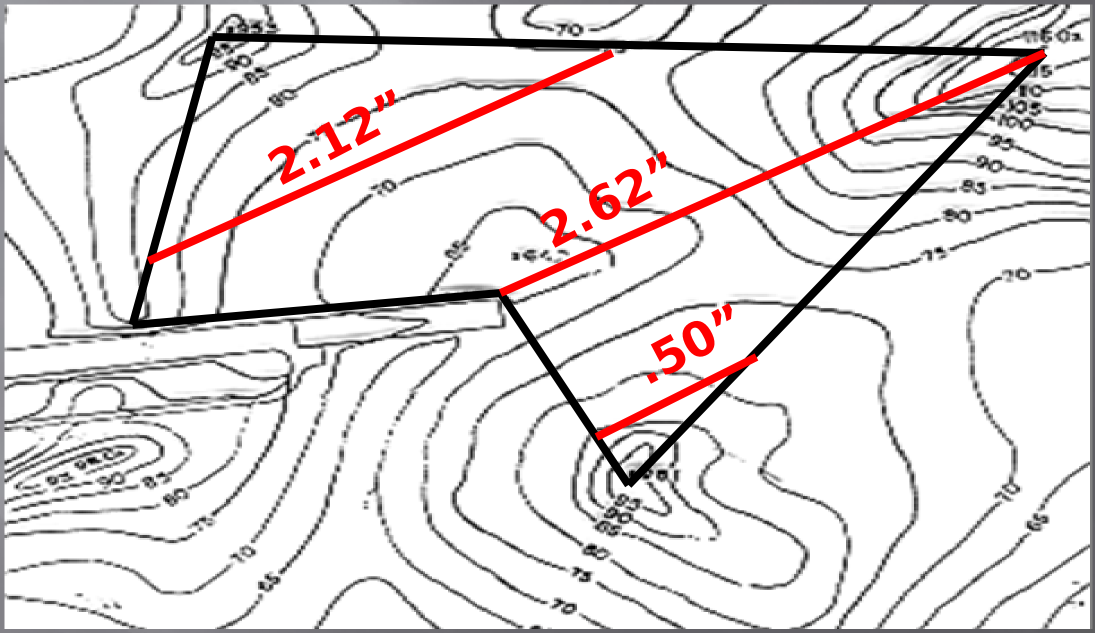
LOCATE THE LONGEST, STEEPEST GRADIENT WITHIN THE DRAINAGE AREA



USE A STRAIGHT EDGE TO DRAW A SERIES OF LINES PARALLEL TO THE BASE LINE, ONE INCH APART



- Measure the length of each line in the drainage area.
- Add all the lengths together
- This is the map area in square inches



- **2.12” + 2.62” + .50” = 5.25 square inches**

CONVERSION (INCHES TO ACRES)

- For a more accurate determination, you can draw the lines ¼” or ½” apart from the base line.

- If ¼” spacing is used, you must take total length of lines and divide by 4.

- If ½” spacing is used, you must take total length of lines and divide by 2.

CONVERSION (INCHES TO ACRES)

- Determine how many feet are in one inch on the map.

  - Example: MAP Scale: 1 : 5,000

    $$5000 \div 12 = 416.67 \text{ ft.}$$

  - 1 inch on the map is 416.67 ft

CONVERSION (INCHES TO ACRES)

- Determine how many square feet are in one square inch on the map.

$$416.67^2 = 173{,}613.88$$

One square inch on a map contains 173,613.88 square feet on the ground

CONVERSION (INCHES TO ACRES)

Total square feet in the drainage area?

5.25” x 173,613.88 = 911,472.87 SqFt

- **Now convert square feet to acres.**

911,472.87 ÷ 43,560 = 20.92 or

A = 21 acres

FORMULA

$$Q = 2 \times A \times R \times C$$

$$A = 21$$

$$Q = 2 \times 21 \times R \times C$$

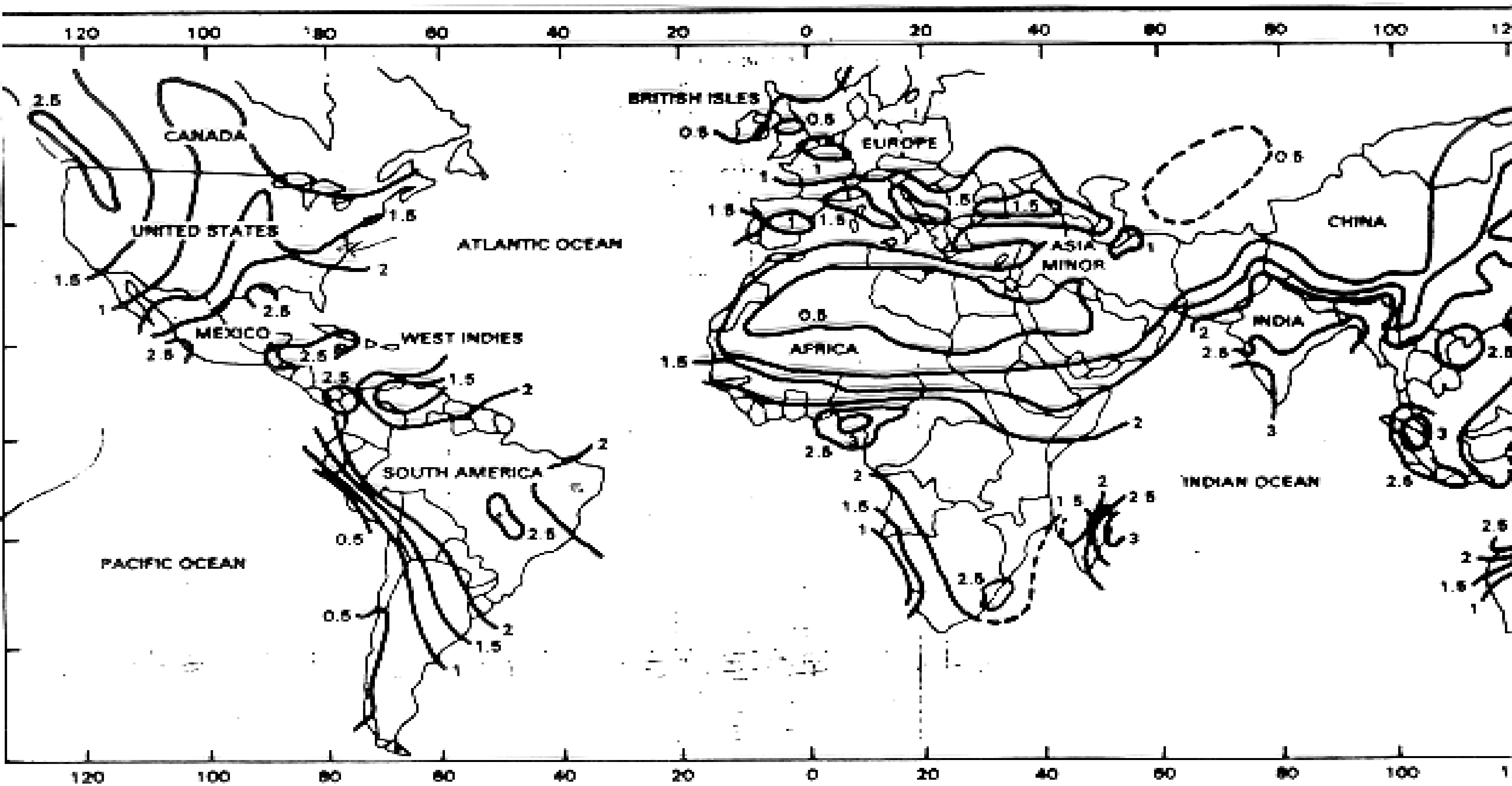
DEMONSTRATION

- Example on page 6 of the student handout
  - Follow along with the demonstration

Practical Application

- Perform the Practical Exercise Worksheet #1

RAINFALL INTENSITY



RAINFALL INTENSITY

- The Project is in Eastern North Carolina
  - It falls between 1.5 and 2.0, always use the larger number.
- Formula

$$Q = 2 \times 21 \times 2 \times C$$

RUNOFF COEFFICIENT

- The ratio of runoff to rainfall. The amount of water expected to drain from an area as the result of a specific amount of rainfall.
- It is expressed as a decimal.
- There are three primary factors that affect the percentage;
  - Soil type
  - Surface cover
  - slope

SOIL TYPE

- Porous soil - A large portion of the soil will infiltrate leading to a smaller runoff coefficient

- Man made surfaces – Like asphalt, concrete, and compacted gravel or macadam will result in a higher runoff coefficient

SURFACE COVER

- To use table 6-1, you need to understand the following terms
- Without Turf – Is ground that is completely bare
- With Turf – Is ground that is covered with vegetation.
- If the area has some vegetation but is not completely covered, use the higher without turf value

SLOPE

- As terrain becomes steeper, water flows sooner and more rapidly. This allows less time for infiltration to occur and results in the C value becoming larger for the natural cover or soil categories.

USCS

- Use the Unified Soil Classification System (USCS) to select the PREDOMINANT soil type.

- This will be needed for the left column of table 6-1 (the next slide).

- If the area is wooded or covered with asphalt, concrete, gravel or macadam simply lookup the “C” value in the left hand column.

FINDING THE RUNOFF COEFFICIENT

UNIFIED SOIL CLASSIFICATION
INCLUDING IDENTIFICATION AND DESCRIPTION

Major divisions		FIELD IDENTIFICATION PROCEDURES (excluding particles larger than 3 inches and basing fractions on stimated weights)	GROUP SYMBOLS	TYPICAL NAMES	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS More than half of materials is larger than No. 200 sieve size (The No. 200 sieve size es about the smallest particle visible to the naked eye) — GRAVELS More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the 1/4" size may be used as equivalent for the No. 4 sieve size)	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentage of sand and gravel, max. size; angularity, surface condition, and hardness of the coarse grains; local or geological name and other pertinent descriptive information, and symbol in parentheses	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between one and 3
		Predominantly one size or a range of sizes with same intermediate sizes missing	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW
	GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	Silty gravel, poorly graded gravel-sand sift mixtures	For undisturbed soils add information on stratification, degree of compact-ness, cementation, moisture conditions and drainage characteristics	Atterberg limits above "A" line with PI greater than 7 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
		Plastic fines (for identification procedures see CL below)	GC	Clayey gravels, poorly graded gravel-sand clay mixtures		Atterberg limits below "A" line or PI greater than 7
SANDS More than half of coarse fraction is smaller than No. 4 sieve size	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amount of all intermediate particle sizes	SW	Well graded sands, gravelly sands, little or no fines	EXAMPLE	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between one and 3
		Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Poorly graded sand, gravelly sands, little or no fines	Silty sand gravelly; about 20% hard, angular gravel particle $\frac{1}{2}$ - in maximum size; rounded and subangular sand grains coarse to fine; about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM)	Not meeting all gradation requirements for SW
	SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see CL below)	SM	Silty sand, poorly graded sand-silt mixtures		Atterberg limits below "A" line or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
		Plastic fines (for identification procedures see CL below)	SC	Clayey sand, poorly graded sand-clay mixtures		Atterberg limits above "A" line with PI greater than 7

Use grain size curve in indentifying the fractions as given under field identification

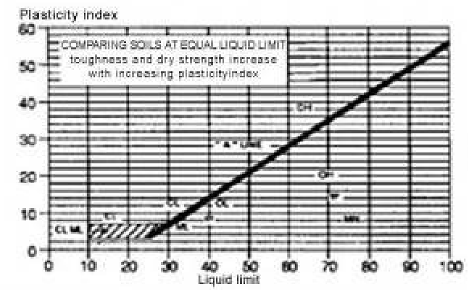
Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follow:
Less than 5% — GW, GP, SW, SP
More than 12% — GM, GC, SM, SC
5% to 12% — Borderline cases requiring use of dual symbols

IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN No 40 SIEVE SIZE

Major divisions		DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)	GROUP SYMBOLS	TYPICAL NAMES	INFORMATION REQUIRED FOR DESCRIBING SOILS
FINE GRAINED SOILS More than half materials is smaller than No. 200 sieve size	SILTS AND CLAYS Liquid limit less than 50	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sand with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; color in wet condition, odor, if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
		Medium to high	None to very slow	Medium	OL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	MN	Organic silts and organic silt-clays of low plasticity	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoided strates, moisture and drainage conditions
	SILTS AND CLAYS Liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	OL	Inorganic silt, micaceous or diatomaceus fine sandy or silty soils, elastic silts	
		High to very high	None	High	CH	Inorganic clays of high organic plasticity	EXAMPLE:
		Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity	Clayey slit, brown, slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess, (ML)
HIGHLY ORGANIC SOILS		Readily identified by color, odor, spongy feel and frequently by fibrous texture			Pt	Peat and other organic soils	

PLASTICITY CHART

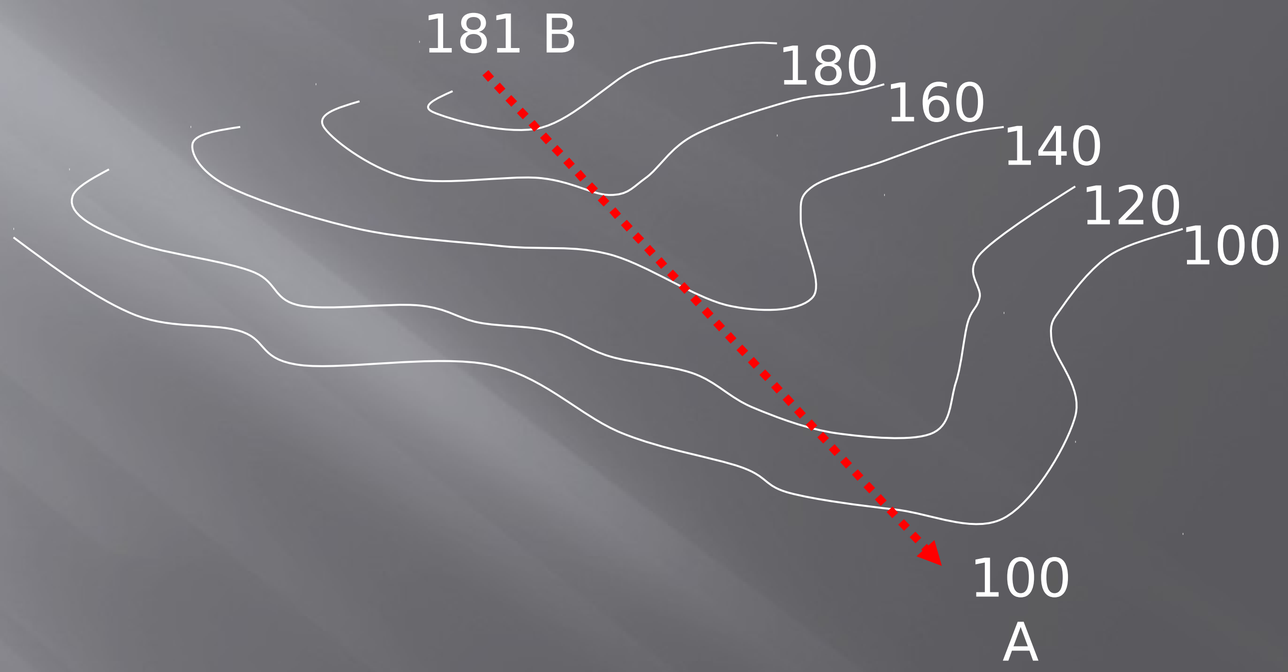
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS



SLOPE PERCENTAGE

- Indentify the slope on the map.
- Find the difference from the top to the bottom of the slope

SLOPE PERCENTAGE



Elevation B =181m
Elevation A =<u>100</u>m
Difference in elevation (Vd) 81**m**

Horizontal Distance **=4150m**

$\frac{Vd}{Hd}$ *X100=* *% of Slope*

$$\frac{81}{4150} X\ 100 = 1.9\%$$

TURF/SAFETY

- TURF: If the soil is not covered, determine whether the area is with or without turf

- SAFETY: In all cases where you have more than one possible runoff coefficient, use the highest value

Soil or Cover Classification	C VALUES					
	Slope ≤ 2 %		Slope > 2 & < 7%		Slope ≥ 7%	
	w/turf	w/o turf	w/turf	w/o turf	w/turf	w/o turf
GP, SW, SP	.10	.20	.15	.25	.20	.30
, **SM**d, ML, Pt	.30	**.40**	.35	.45	.40	.50
, GC, SMu, SC DL, CH, OH	.55	.65	.60	.70	.65	.75
ded area	.20	.20	.20	.20	.20	.20
halt Pavement		.95		.95		.95
rete ment		.90		.90		.90
vel/macadam		.70		.70		.70

RUNOFF COEFFICIENT (EXAMPLE)

- Your drainage area is made up of ML soil, with 49% turf and a slope of 2%.
- Looking at Table 6-1 you should come up with 0.40.
- Now in final formula from

$$Q = 2 \times 21 \times 2 \times .40$$

- The Answer :

$$Q = 33.6 \text{ CFS}$$

WATERWAY AREA

- Expedient culvert and ditch design is based on the waterway area.
- The hasty method deals with waterway area.
- The field estimate method deals with peak volume of storm water runoff (Q).

EQUATION

Q = PEAK VOLUME OF STORM WATER RUNOFF

V = VELOCITY OF WATER, IN FEET PER SECOND (FPS)

Aw = WATERWAY AREA, IN SQUARE FEET

$$Q = VAw$$

EQUATION

- For expedient purposes, you will always use a velocity of 4 fps for design of expedient drainage structures.

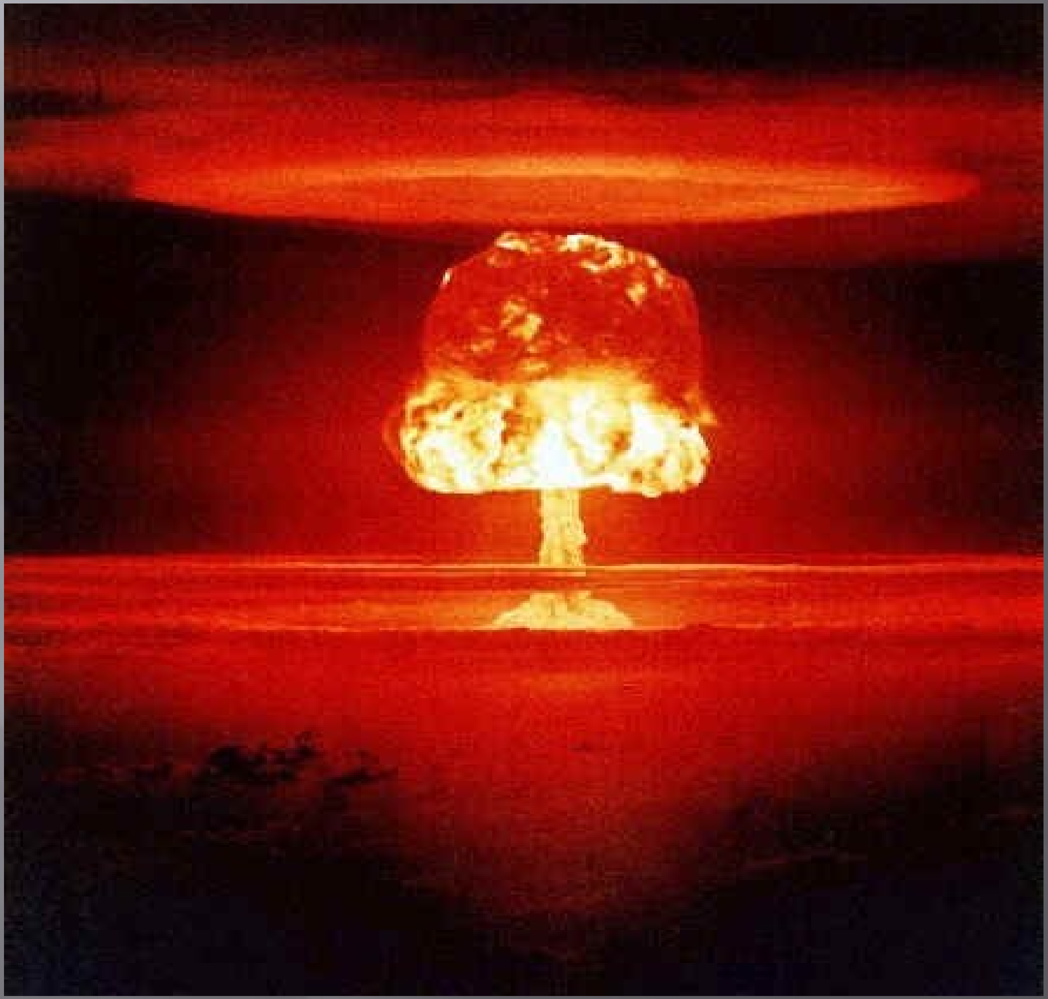
- Example
  - Q = V x Aw (divide both sides by V)
  - The Results are:
    - Q ÷ V = Aw (Using the previous calculation from your handout of 33.6 cfs)
- Final answer
  - 33.6 (cfs) ÷ 4 (constant) = 8.4 sqft (Aw, Area of waterway)

SAFETY FACTOR

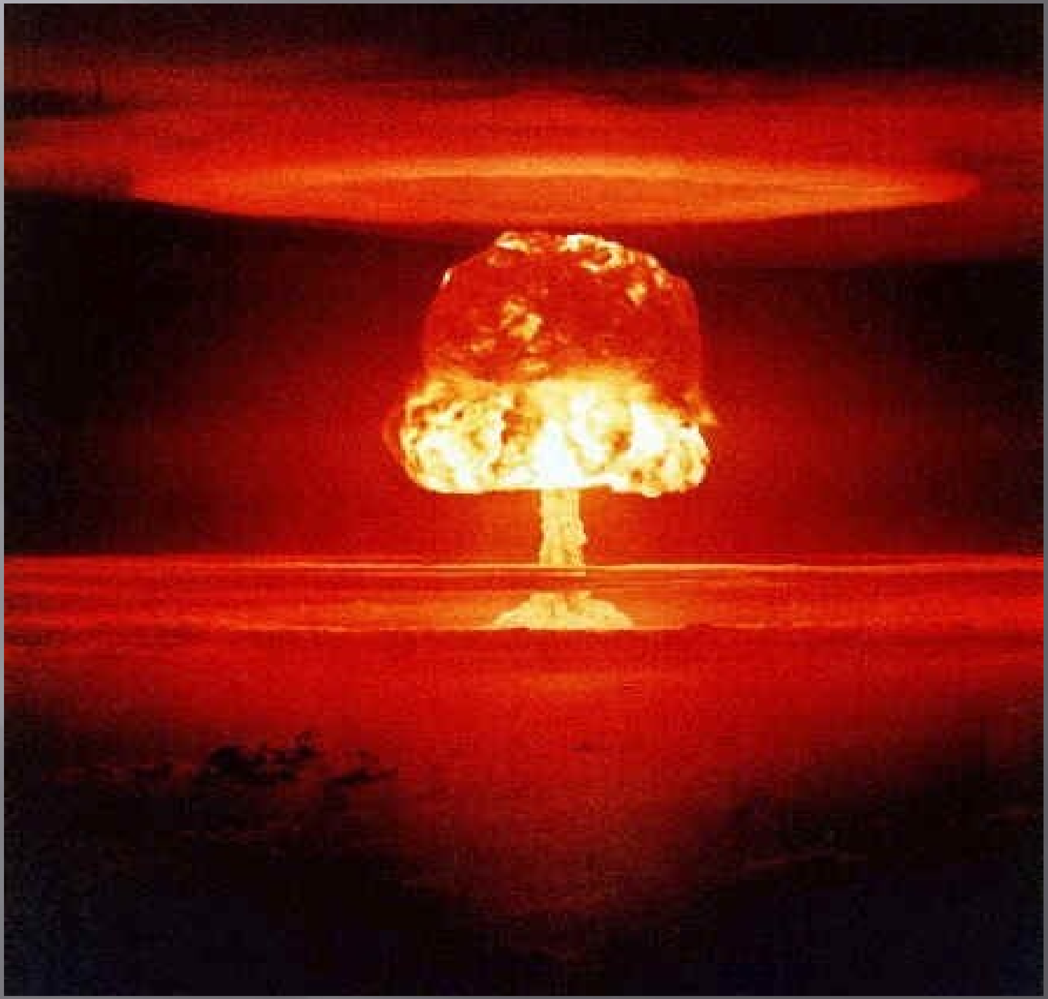
- As with the hasty method, you rarely design a drainage system to flow completely full.
- You must apply a safety factor (Ades)

- Ades = 2 x Aw
- Ades = 2 x 8.4
- Ades = 16.8 sqft

DEMONSTRATION AND PRACTICAL APPLICATION



QUESTIONS??



DRAINAGE DITCHES

TRIANGULAR V-DITCHES

- Triangular (V) ditches are used to move small amounts of water.
  - $Q \leq 60$ cfs or $A_w \leq 15$ sqft

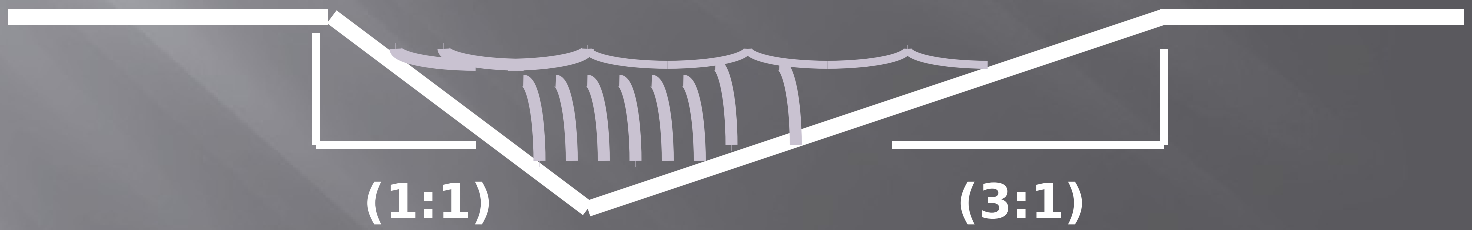
TRIANGULAR V-DITCHES

- SYMMETRICAL
  - Both sides of the ditch are inclined equally
- NON_SYMMETRICAL
  - Each side of the ditch are inclined differently
- Ensure the appropriate side-slope ratio is selected to serve its designed purpose.
- If the side walls are too step it invites excessive corrosion and ditch clogging.

TRIANGULAR V-DITCHES

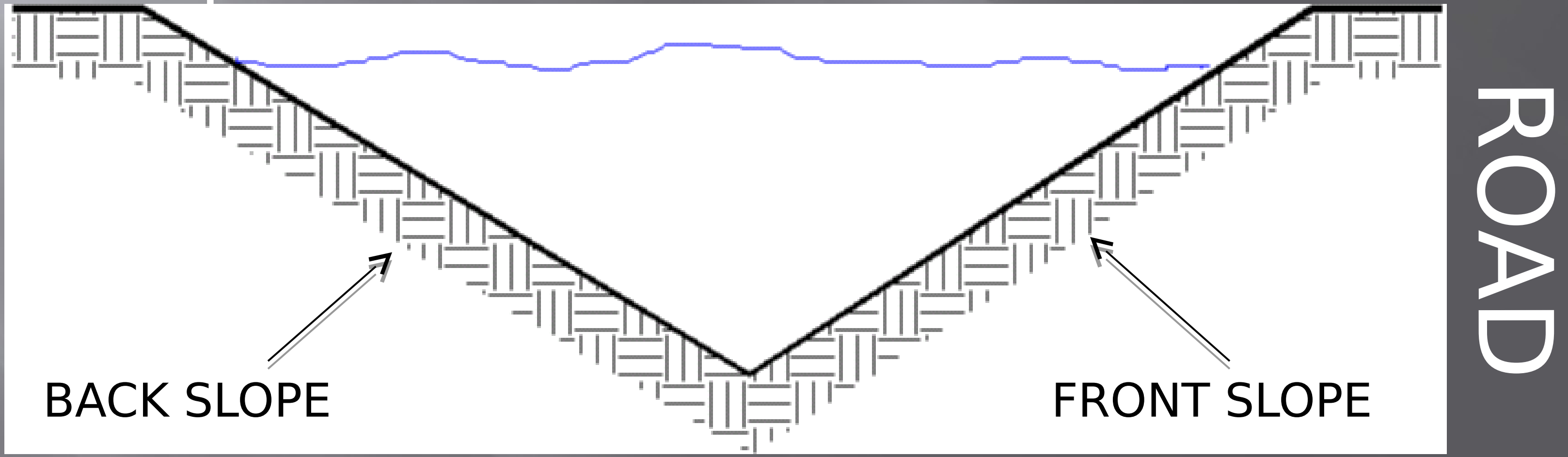
Ditches have two sloped sides, with each having a respective slope ratio. This is expressed as horizontal feet to vertical feet.

Example: 3 : 1 is a side slope of 3 feet horizontal to a 1 foot vertical.



TRIANGULAR V-DITCHES

- The sidewall of a ditch located adjacent to the shoulder is called the front slope of the ditch.
- The far slope, called the back slope, is simple an extension of the cut face of the



TRIANGULAR V-DITCHES FORMULA (DEPTH)

$$D = \sqrt{\frac{Ca \times 2}{X + Y}} + 0.5$$

D = Ditch depth in feet. Rounded to two decimal places.

Ca = Channel area computed previously.

X =Horizontal run of the front slope ratio.

Y = Horizontal run of the back slope ratio.

0.5 = Safety factor constant. (1/2 foot freeboard)

TRIANGULAR V-DITCHES FORMULA (WIDTH)

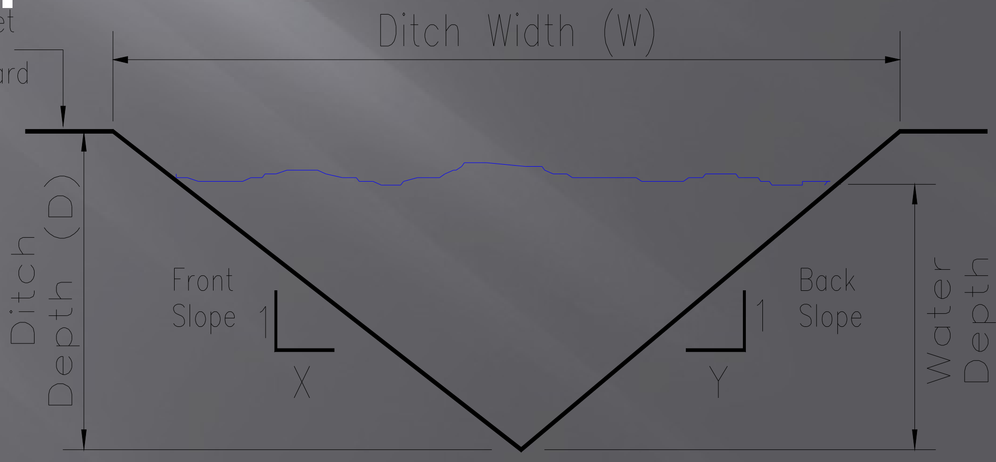
Ditch Width: W = D x (X + Y)

W = Ditch width in feet. Rounded to two decimal places.

D = Ditch depth in feet.

X = Front slope ratio.

Y = Back slope ratio.



EXAMPLE

Using your previous Ades of 16.8 sqft and a front slope of 3 : 1 and a back slope 1 : 1, calculate the depth and width of the ditch.

$$D = \sqrt{\frac{16.8}{3+1}} + 0.5$$

$$D = \sqrt{\frac{16.8}{4}} + 0.5$$

$$D = \sqrt{4.2} + 0.5$$

$$D = 2.05 + 0.5$$

$$D = 2.55'$$

$$W = D \times (X + Y)$$

$$W = 2.55' \times (3 + 1)$$

$$W = 2.55 \times 4$$

$$W = 10.20'$$

PRACTICAL APPLICATION

- Triangular Ditch Calculations Worksheet

TRAPEZOIDAL DITCHES

- Installed for larger runoff requirements, usually 60 cfps / 15 aw or greater.
- The designer of the ditch determines the bottom width based upon the cutting edge of the equipment used.

FORMULA

Ditch Depth: $D = \frac{Aw}{W} + 0.5$

D = Ditch Depth in feet. Rounded to two decimals

Ca = Channel area in square feet.

W = Width of ditch (bottom) in feet.

0.5 = Safety factor constant. (1/2 foot of freeboard)

EXAMPLE

With an AW of 18.75, using a D7G to excavate

the ditch, determine the ditch depth.

18.75 aw ÷ 7.25’ (D7 width) + .5 (freeboard) =

3.1’ deep

–

PRACTICAL APPLICATION

- Trapezodial Ditch worksheet

EROSION CONTROL

EROSION CONTROL METHODS

- There are several methods of erosion control.

- The desirable gradient for a ditch is between 05 and 2%. Ditches larger than 2% will require erosion control.

- Examples:
  - Ditch Linings
  - Check Dams

DITCH LINING

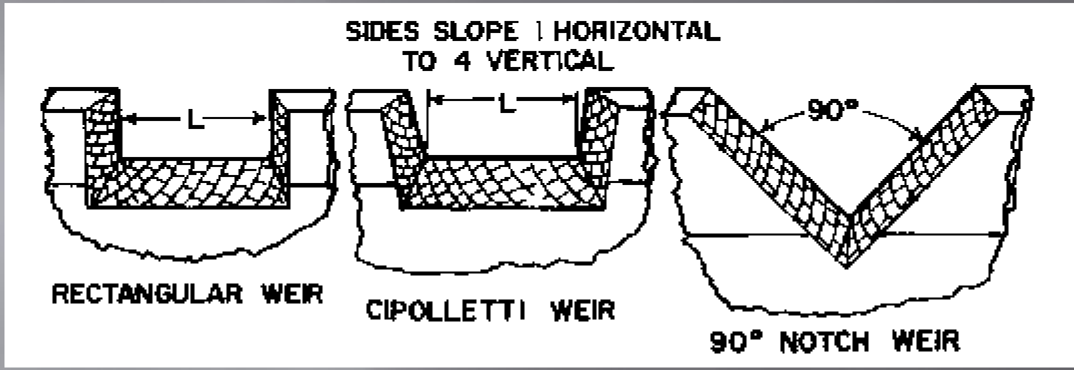
- May be lined to prevent erosion.
- Examples:
  - Concrete
  - Asphalt
  - Rock
  - Mortor
    - Does not decrease the flow but protects the soil. Expensive and not always readily available
  - Grass
    - Protects the soil, slow the flow and is cheap

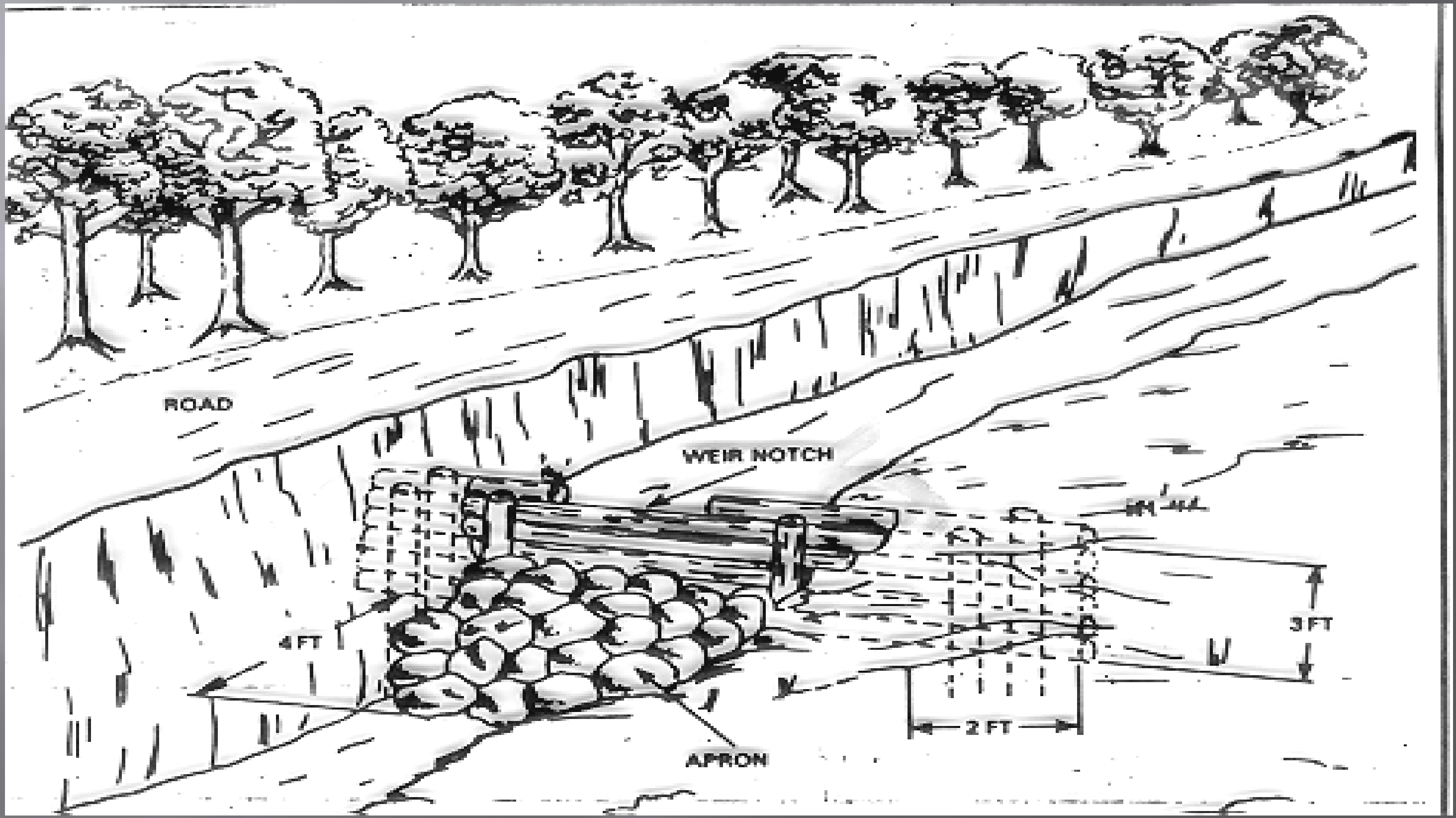
EXAMPLES

CHECK DAMS

CHECK DAMS

- Constructed with 6-8” diameter timbers.
- Set 2’ into the sides of the ditch.
- Weir notch is 6” deep and a minimum of 12” long.
- 4’ of rock apron for every 1’ of dam height.
- The top of the check dam should be at the high water mark, when high water mark is not visible, place check dam 1’ below the top of the ditch.


SIDES SLOPE 1 HORIZONTAL
TO 4 VERTICAL
L
L
90°
RECTANGULAR WEIR
CIPOLLETTI WEIR
90° NOTCH WEIR


ROAD
WEIR NOTCH
4 FT
3 FT
2 FT
APRON

DAM SPACING

- Will have a minimum spacing of 50 feet.
- Should be placed as far apart as possible, while achieving the desired gradient.

Spacing Calculations:

$$S = \frac{100\ (H)}{A - B}$$

S = Dam Spacing
100 = Constant
H = Height of Dam
A = Present Slope
B = Desired Slope

DAM SPACING EXAMPLE

What spacing will be needed for a 4’ high check dam with a 10% slope.

$$S = \frac{4 \times 100}{10 - 2}$$

S = 50’

QUESTIONS

CULVERTS

- Two classifications
  - Permanent (refer back to the Military Roads class)
  - Expedient
- Different types of material used
  - Corrugated metal
  - Concrete
  - Vitrified Clay (VC)
  - Polyvinyl Chloride (PVC)
  - Timber
  - Ect.

CULVERTS

- Timber Box
  - Good workmanship
  - Large timber
  - Strong enough to support heaviest vehicle traffic
  - Minimum of 12” cover
- Corrugated Metal Pipe Culvert (CMP)
  - 8”-72” diameter
  - Shipped in 26” long half sections
  - Bolted in every hole

CULVERTS

- Concrete pipe
  - Comes in any size
  - Comes in different shapes (circle, square, etc)
  - Overall strength
  - Smooth interior surface
  - Higher amount of water flow
  - Transportation considerations

MAXIMUM ALLOWABLE CULVERT DIAMETER

- Permanent culverts are selected based on their diameter.
- There are two maximum diameter (Dmax) equations.

  - Fills greater than 36 inches

$$Dmax = 2/3 \times F$$

  - Fills less then 36 inches

$$Dmax = F - 12$$

FILLS GREATER THAN 36”

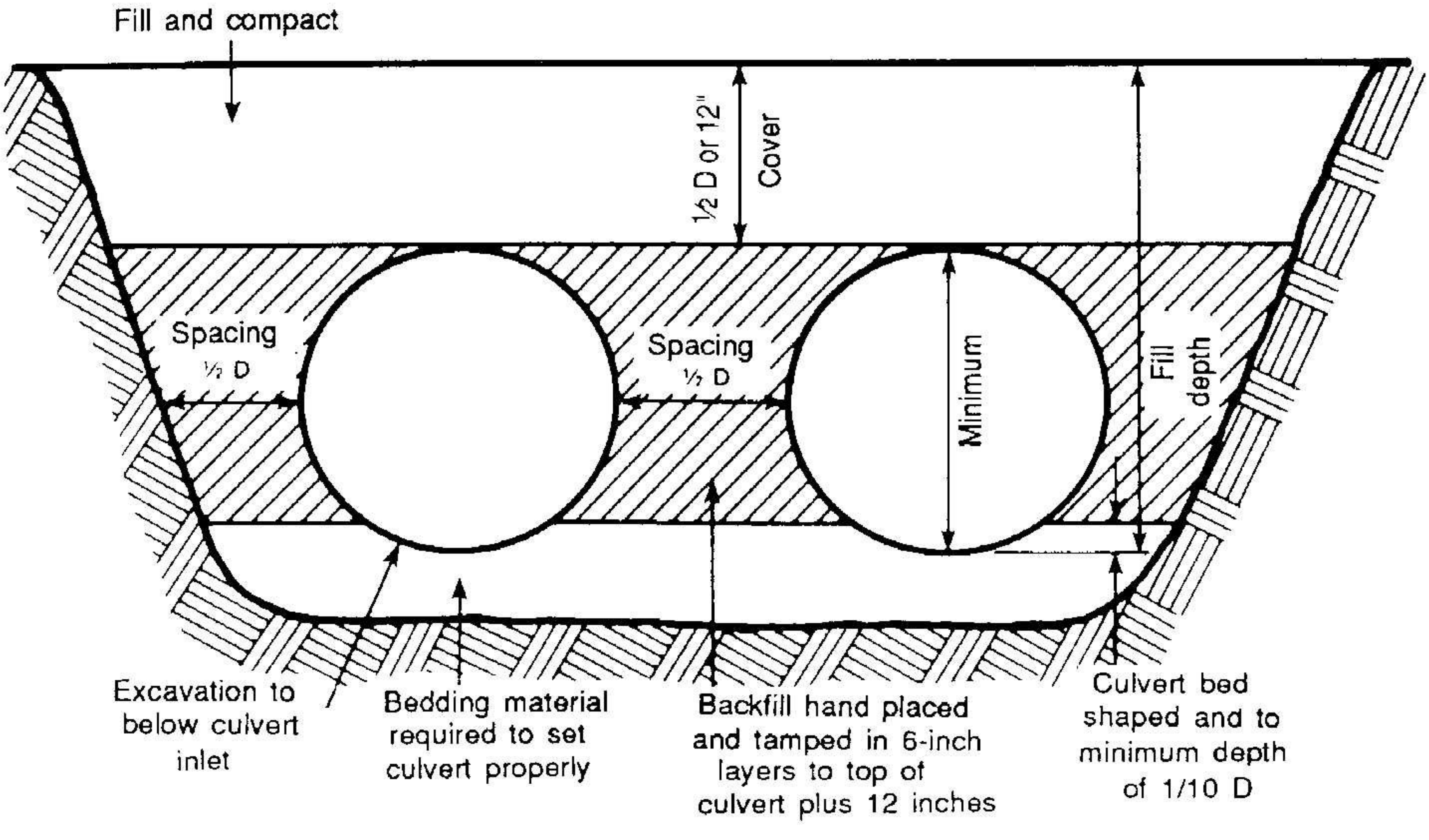
Dmax = 2/3 x Fill

Dmax = Maximum culvert diameter in inches rounded to two decimal places.

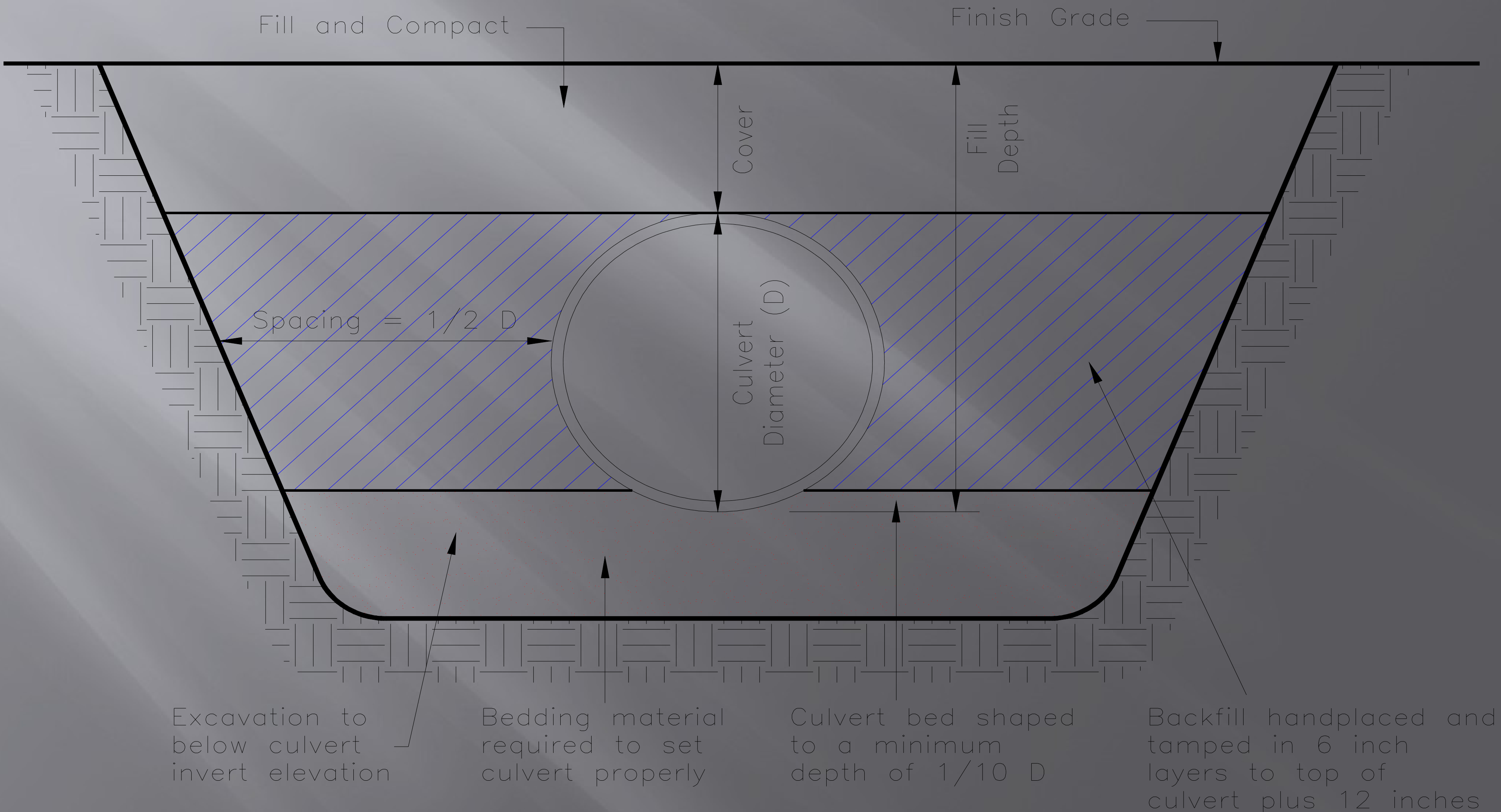
2/3 = A constant that represents the minimum fill depth required for the maximum diameter of culvert to be calculated.

Fill = Fill depth in inches rounded to two decimal places.

MAXIMUM ALLOWABLE CULVERT DIAMETER



MAXIMUM ALLOWABLE CULVERT DIAMETER



EXAMPLE

$$D_{max} = 2/3 \times F$$

$$F = 6' \times 12'' = 72''$$

$$D_{max} = 2/3 \times 72''$$

$$D_{max} = 48 \text{ inches}$$

PRACTICAL APPLICATION

- Complete the DMAX worksheet

CULVERT MATERIALS

- Several Factors
  - Economical Diameter
  - Number of pipe required
  - Culvert Length
  - Order Length

ECONOMICAL DIAMETER

- You want to save material.
- Put in the least amount of culverts.
- They need to equal or exceed the design area.
- Manpower requirements

PIPES REQUIRED

- To find the most economical size, you must divide the design area by the end area of several different pipe sizes.
- Use the largest pipe that satisfies the fill and cover requirements as a starting point.
- Work your way down in size until the amount of pipes needed changes.
- Once changed, we have reached and passed our optimal design. Go back to the prior number and pipe demision.

ECONOMICAL DIAMETER FORMULA

$$N = \frac{Ades}{PEA}$$

N = Number of Pipes

Ades = Design Cross Section

PEA = Pipe End Area, cross sectional end area of culvert in ft squared

COMMON CULVERT SIZES

Maximum Diameter (")	Cross Sectional Area (sqft)
12"	00.79 sqft
18"	01.77 sqft
24"	03.14 sqft
30"	04.91 sqft
36"	07.07 sqft
42"	09.62 sqft
48"	12.57 sqft
60"	19.64 sqft
72"	28.27 sqft

EXAMPLE

N48” = Ades ÷ A48

N48” = 17.5 ÷ 12.57 = 1.4 or 2

N48” = (2) 48” Pipes

N42” = Ades ÷ A42

N42” = 17.5 ÷ 9.62 = 1.8 or 2

N42” = (2) 42” Pipes

N36” = Ades ÷ A36

N36” = 17.5 ÷ 7.07 = 2.5 or 3

N36” = (3) 36” Pipes

CULVERT LENGTH

Now that we've determined that we will need (2) 42" diameter culverts, we must now calculate the culvert length. Use the following formula to do so:

(DL x SL) + ROADWAY WIDTH + (DR x SR) = CL

Culvert Length

Note: After calculating culvert length, ensure you round up to an even number.

EXAMPLE

CL = (7 x 2) + 22’ + (6 x 3)

CL = 14’ + 22” + 18’

CL = 54’ + 2’ (no headwalls on the exhaust end)

CL = 56’

ORDER FORMULA

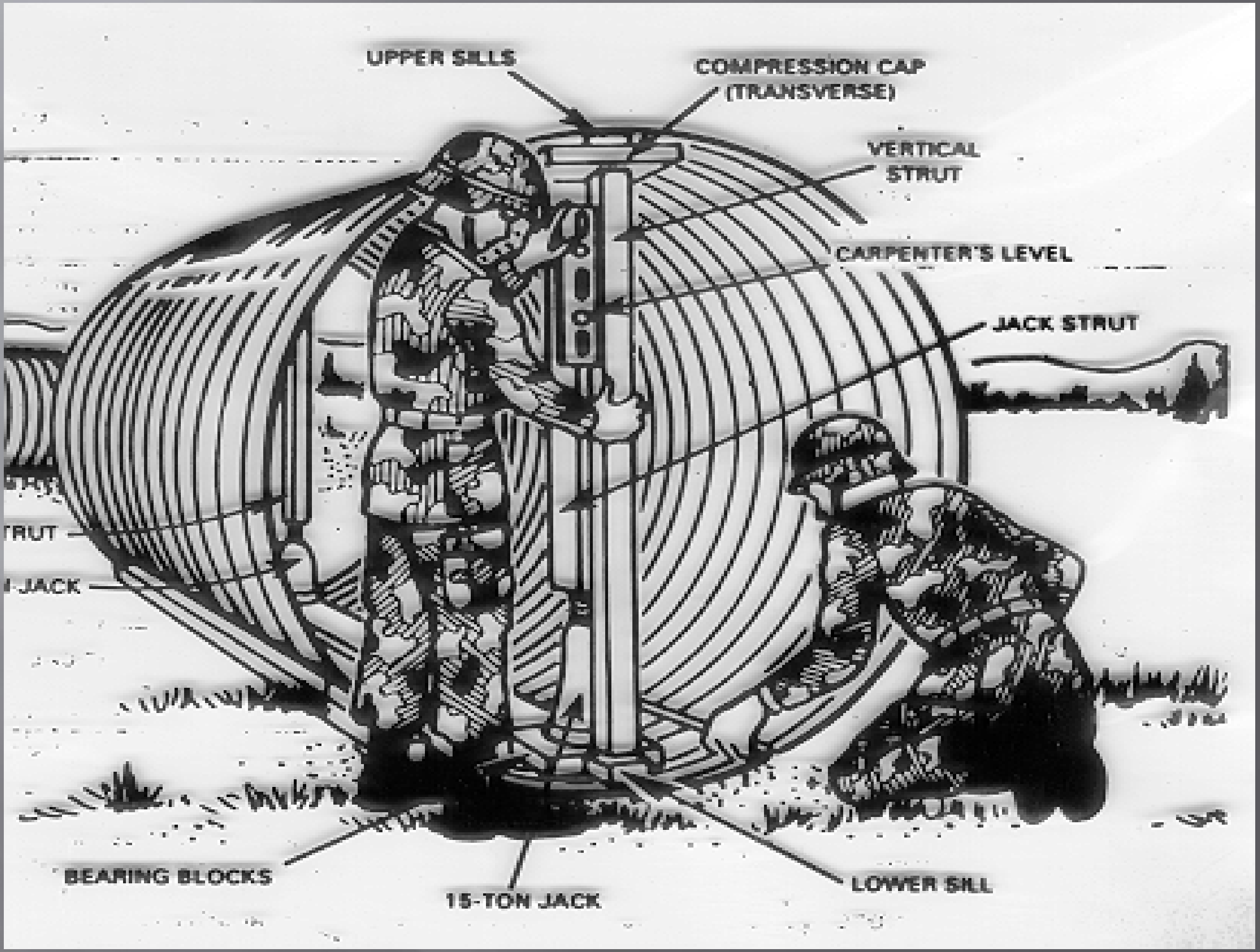
OL (order length) = CL x # of pipes x 1.15 (waste)

OL = (56’ X 2) 1.15

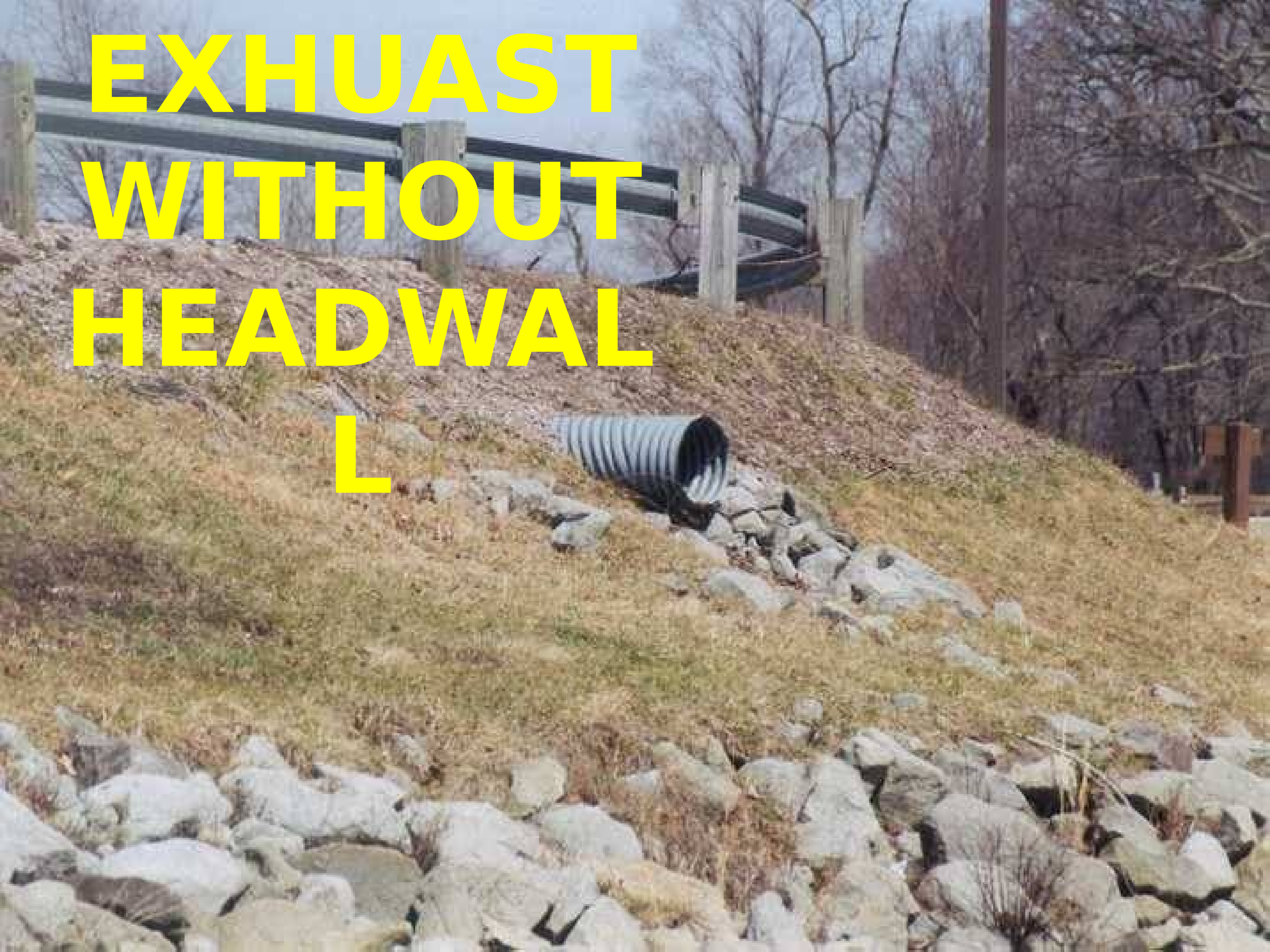
OL = (112) 1.15

OL = 128.8’ or 130’ of pipe needed

STRUTTING


UPPER SILLS
COMPRESSION CAP
(TRANSVERSE)
VERTICAL
STRUT
CARPENTER'S LEVEL
JACK STRUT
BEARING BLOCKS
15-TON JACK
LOWER SILL


HEADWAL
L


EXHUAST
WITHOUT
HEADWAL
L

QUESTIONS